REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	03/08/76	

4. TITLE AND SUBTITLE
DETERMINATION OF DECONTAMINATION CRITERIA DIMP AND DCPD (U)

5. FUNDING NUMBERS
DAMD17 75 C 5069

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
AEROJET ORDNANCE & MANUFACTURING COMPANY
DOWNEY, CA

8. PERFORMING ORGANIZATION REPORT NUMBER
81339R03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
FORT DETRICK (FREDERICK, MD.)
FREDERICK, MD

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

THIS IS A PROGRESS REPORT ON AEROJETS' STUDIES OF EXPERIMENTS CURRENTLY UNDERWAY (E.G., PLANT GROWTH AND DIMP AND DCPD LYSIMETER TESTS). THE FULL SCALE LYSIMETER TESTS ARE CONTINUING. THE PRELIMINARY SOIL CULTURE EXPERIMENTS ARE CONTINUING IN THE SMALL POTS. THE PURCHASE ORDERS FOR A NEW GREENHOUSE HAVE BEEN WRITTEN AND A BUILDER SELECTED. THIS REPORT INCLUDES SEVERAL TABLES OF "DIMP" CONTENT OF LYSIMETERS." THE PLANTS GROWN IN THE HYDROPONIC BATHS ARE STILL BEING MONITORED CHEMICALLY AS TO THEIR UPTAKE OF DIMP. MOST OF THE PLANTS HAVE REACHED THE HARVEST STAGE AND ARE BEING COLLECTED FOR FINAL ANALYSIS. SEEDS ARE BEING SEPARATED WHERE POSSIBLE.

14. SUBJECT TERMS	15. NUMBER OF PAGES
CONTAMINANTS, FLORA, CHEMICALS, LYSIMETER, SOIL	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED			

81339R03
Original

AEROJET ORDNANCE AND MANUFACTURING COMPANY
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81339R03
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DETERMINATION OF DECONTAMINATION CRITERIA

DIMP AND DCPD (U)

Report No. 1953-01(08)MP

Contract DAMD-17-75-C-5069

to

Rocky Mountain Arsenal
Information Center
Commerce City, Colorado

U.S. ARMY, Ft. Detrick
Fredrick, Maryland 21701

Prepared by: P. A. O'Donovan
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Date: 8 March 1976

No. of Pages: 20

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Progress on items proposed for action during February, 1976 is discussed in the following paragraphs.

Full Scale Lysimeter Tests

The full scale lysimeter tests are continuing. These tests consist of adding two inches (12,887cc) of distilled water containing 20 parts per million (ppm) of diisopropyl methyl phosphonate (DIMP) to the surface of each lysimeter and allowing it to percolate through a five foot column of the soil with both tensiometer liquid samples and coring soil samples analyzed at various times to follow the progress of the DIMP in the soil. The addition of the contaminated water to the lysimeter was originally planned for one application per week. This has been followed with the exception of the Fullerton soil. In this particular case, the next addition will be made two weeks subsequent to the last addition because on the regular addition day water was still standing on the surface indicating that the flow rate through the Fullerton soil was decreasing. Figure 1 shows the drainage efficiency data (output volume ÷ 12887) for the five DIMP lysimeters through this period. This data is tabulated in Table 1.

Water samples collected from the tensiometers indicate that there is some passage of DIMP in the Ventura sample but none of significance in the other samples. Since the bottom, or drain, concentration level of the Ventura sample is relatively high as is the upper layer, while the intermediate layers are quite low in concentration, the possibility arises that this may be due to channeling. This channeling, if present, could be caused during the soil sampling process. Methods for preventing this will be considered. This data is shown in Table 2.

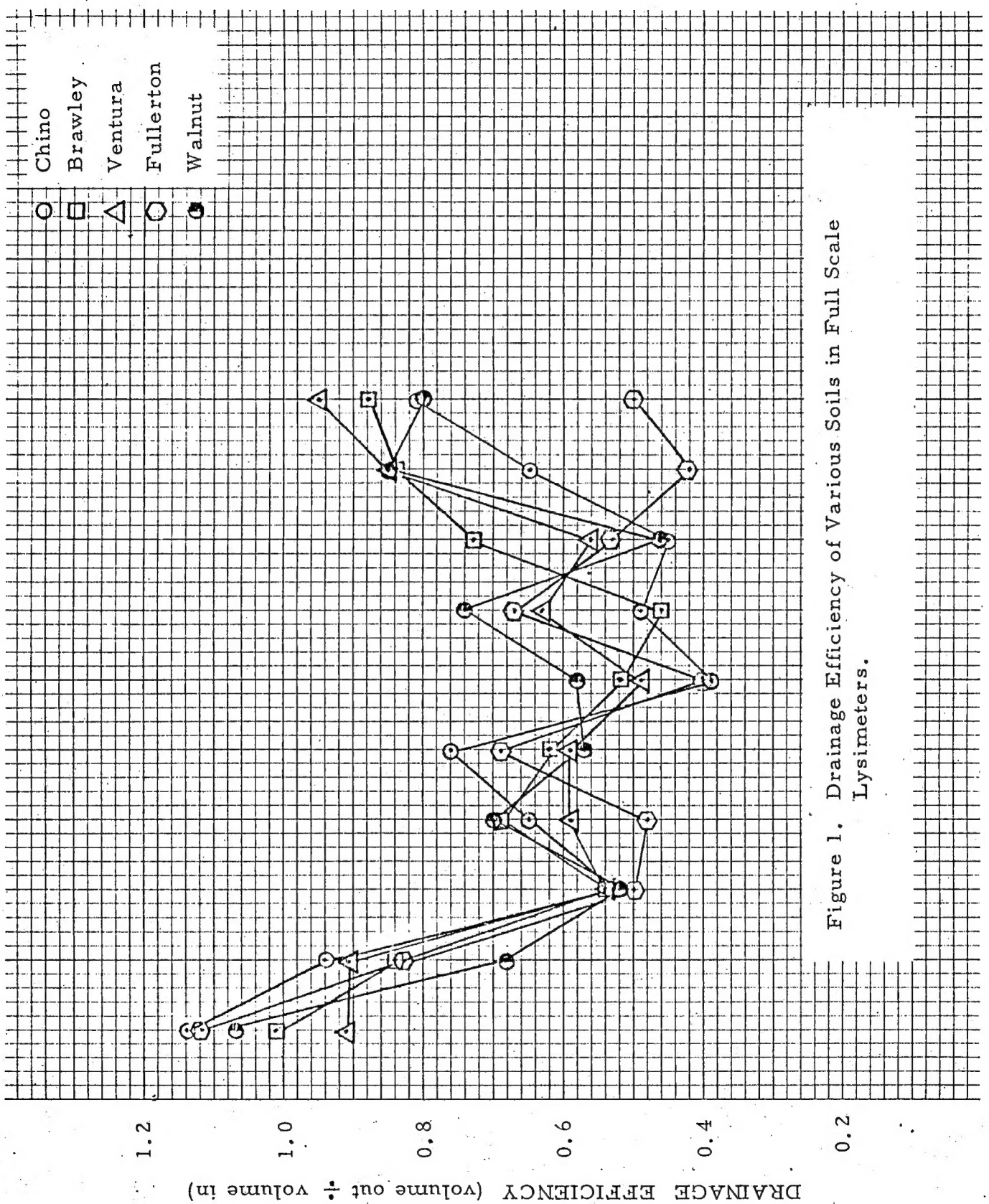

Figure 1. Drainage Efficiency of Various Soils in Full Scale Lysimeters.

Table 1.

"Drainage Efficiency" - Full Scale Lysimeters

Type of Soil	TIME (weeks)									
	1	2	3	4	5	6	7	8	9	10
Chino	1.14	0.94	0.53	0.65	0.76	0.39	0.49	0.45	0.65	0.81
Brawley	1.01	0.84	0.54	0.69	0.62	0.52	0.46	0.73	0.84	0.88
Ventura	0.91	0.91	0.54	0.59	0.59	0.49	0.63	0.56	0.85	0.95
Fullerton	1.12	0.83	0.50	0.48	0.69	0.40	0.67	0.53	0.42	0.50
Walnut	1.07	0.68	0.52	0.70	0.57	0.58	0.74	0.46	0.85	0.80

Table 2
DIMP Content of Tensiometer Water Samples

Type	Depth	Average From Previous Month	DIMP (ppm) Days Since Inoculation			
			51	58	66	73
Ventura	6"	1.77	----	0	1.59	1.20
	18"	0	0.78	0	----	0.21
	30"	0	0.22	0	0.16	0.70
	42"	0.17	0.41	0.33	0.50	0.34
	54"	0.69	0.21	0.13	0.38	0.38
	60"	2.23	2.04	1.85	1.98	3.25
Chino	6"	0.12	0.74	0.90	----	----
	18"	0.02	2.12	0.82	0.87	0.43
	30"	0	0.32	----	0.41	----
	42"	0	----	----	----	0.20
	54"	0.18	----	0	0	0
	60"	0	0	0	0	0.19
Fullerton	6"	7.25	2.50	0	4.4	8.95
	18"	1.27	1.47	----	1.10	1.05
	30"	0.09	0.40	0.87	0.82	0.38
	42"	1.84	0.97	4.36	0.11	0
	54"	0.23	0	0	0.10	0
	60"	0.55	0	0.36	0.52	0.74
Walnut	6"	3.86	----	0.31	0.26	----
	18"	2.30	----	0	----	2.78
	30"	0.58	----	0.19	0.81	1.17
	42"	0	0	5.07	0.31	1.11
	54"	0.20	0	0	0	0
	60"	0	0	0	0.18	0.19
Brawley	6"	2.48	3.02	2.68	2.64	3.98
	18"	0.36	0.73	0.57	1.07	1.43
	30"	0.08	0.53	0.43	----	0.21
	42"	0	0.74	----	0.12	0
	54"	0.26	3.15	----	----	0
	60"	0.27	0.76	0.52	0.36	0.11

Soil samples collected at approximately two months after the original inoculation, and one week after this most recent inoculation showed that DIMP has reached the bottom layer of the Ventura, Brawley and Walnut soils but has not quite penetrated the Chino soil. No sample was taken of the Fullerton soil due to water still standing on the lysimeter surface. The zero or surface layer in this case was taken from the same core position as the rest of the samples. This means that the 0-6" layer has had that surface 1/4" removed prior to analysis. A tabulation of the soil analysis data is shown in Table 3 .

Calculations of percent recovery of DIMP in lysimeter soil were described in last month's report (1953-01(07)MP). Making the assumption of homogeneity within each 6" horizontal section these calculations were repeated at the two month time. Data from these calculations are shown in Table 4 .

Soil Culture

The preliminary soil culture experiments are continuing in the small pots. No analyses were made on these during this report period.

The purchase orders for the new greenhouse have been written and a builder selected. These will be implemented as soon as permission to build has been received from the sponsor.

The soil selected for use in the greenhouse experiments is the Fullerton sandy loam. A truckload of this topsoil has been procured from the same

Table 3

DIMP Content of Soil Samples (ppm)

Depth	Ventura	Chino	Fullerton	Walnut	Brawley
0 (surface)*	3.81	4.87	None Collected	13.94	2.88
0 - 6"	0.97	0.90		1.08	0.82
6 - 12"	0.77	1.60		0	0.60
12 - 18"	0.18	0.85		1.55	0.72
18 - 24"	0	0.96		1.25	0.66
24 - 30"	0	0.52		1.16	0.82
30 - 36"	0.19	0.80		1.00	0.60
36 - 42"	0.37	0.57		0.70	0.33
42 - 48"	0.75	0.31		0.36	0.52
48 - 54"	0.47	0		0.14	0.41
54 - 60"	0.67	0		0.15	0.21

Table 4(a)

DIMP Content of Lysimeters

Ventura Soil	Sample Wt(g)	Total Section Wt. (g)	Conc. of DIMP / Sample (ppm)	Wt. of DIMP in Total Section (g)	% Recovery
Zero -	20.0	19,716	3.81	0.075	
0 - 6"	45.7	45,052	0.97	0.044	
6 - 12"	58.5	57,670	0.77	0.044	
12 - 18"	47.7	47,023	0.18	0.008	
18 - 24"	67.9	66,936	0	0	
24 - 30"	68.1	67,132	0	0	
30 - 36"	47.4	46,727	0.19	0.009	
36 - 42"	59.7	58,853	0.37	0.021	
42 - 48"	91.1	89,807	0.75	0.067	
48 - 54"	94.3	92,962	0.47	0.044	
54 - 60"	101.0	99,567	0.67	0.069	
Total	701.4	691,445		0.381	16.43

Table 4(b)

DIMP Content of Lysimeters

Chino Soil	Sample Wt(g)	Total Section Wt. (g)	Conc. of DIMP / Sample (ppm)	Wt. of DIMP in Total Section (g)	% Recovery
Zero -	2.68	2,642	4.87	0.012	
0 - 6"	47.5	46,826	0.90	0.042	
6 - 12"	76.1	75,020	1.60	0.120	
12 - 18"	70.0	69,007	0.85	0.059	
18 - 24"	82.9	81,724	0.96	0.078	
24 - 30"	71.2	70,190	0.52	0.036	
30 - 36"	68.7	67,725	0.80	0.054	
36 - 42"	74.3	73,246	0.57	0.042	
42 - 48"	68.2	67,232	0.31	0.021	
48 - 54"	77.4	76,302	0		
54 - 60"	75.6	74,527	0		
Total	714.58	704,441		0.464	20.01

Table 4(c)

DIMP Content of Lysimeters

Walnut Soil	Sample Wt.(g)	Total Section Wt. (g)	Conc. of DIMP/Sample (ppm)	Wt. of DIMP in Total Section (g)	% Recovery
Zero	14.2	13,998	13.94	0.195	
0 - 6"	36.0	35,489	1.08	0.038	
6 - 12"	50.1	49,389	0	0	
12 - 18"	48.3	47,615	1.55	0.073	
18 - 24"	45.8	45,150	1.25	0.056	
24 - 30"	36.2	35,686	1.16	0.041	
30 - 36"	33.4	32.926	1.00	0.033	
36 - 42"	44.3	43,671	0.70	0.031	
42 - 48"	34.8	34,306	0.36	0.012	
48 - 54"	33.6	33,123	0.14	0.005	
54 - 60"	93.	91,680	0.15	0.013	
Total	469.7	463,033		0.497	21.43

Table 4(d)

DIMP Content of Lysimeters

Brawley Soil	Sample Wt. (g)	Total Section Wt. (g)	Conc. of DIMP/Sample (ppm)	Wt. of DIMP in Total Section (g)	% Recovery
Zero -	2.6	2,563	2.88	0.007	
0 - 6"	36.7	36,179	0.82	0.030	
6 - 12"	26.8	26,420	0.60	0.016	
12 - 18"	20.5	20,209	0.72	0.015	
18 - 24"	27.8	27,406	0.66	0.018	
24 - 30"	30.9	30,462	0.82	0.025	
30 - 36"	34.9	34,405	0.60	0.021	
36 - 42"	62.4	61,514	0.33	0.020	
42 - 48"	87.8	86,554	0.52	0.045	
48 - 54"	99.9	98,482	0.41	0.040	
54 - 60"	130.2	128,352	0.21	0.026	
Total	560.5	552,546		0.263	11.34

location as the Fullerton lysimeter samples. Dr. Chapman of UCR is preparing recommendations for growing conditions, fertilizing, etc. for use in the greenhouse tests which will utilize wheat, sugar beet , alfalfa, carrot and bean as the test organisms.

To complete the characterization of the various test soils a semiquantitative spectrographic analysis of the topsoils was run. The results of these analyses are shown in Table 5 .

Range Finding Plant Growth Experiments

The plants grown in the hydroponic baths are still being monitored chemically as to their uptake of DIMP. Most of the plants have reached the harvest stage and are being collected for final analysis. Seeds are being separated where possible.

see note at Table 6

Preliminary data on corn yields are shown in Table 6 . In both the DIMP and DCPD (Dicyclopentadiene) cases the fruit yield (whole cob) increased at the lower contamination levels and then decreased severely at the higher levels. The concentration of DIMP in the various corn parts was determined chromatographically and is shown in Table 7 .

This data shows that there is deposition of DIMP in the various corn parts with accumulation in some of the kernels and in all of the husks. The remaining harvested material is being analyzed currently.

The moisture content of the various corn parts was determined and is shown in Table 8.

Table 5

Spectrographic Analyses of Top Soil Samples

SEMIQUANTITATIVE ANALYSIS

	Brawley	Chino	Fullerton	Ventura	Walnut
Si	23.%	30.%	33.%	28.%	28.%
Al-	11.	8.5	5.5	8.8	8.7
Fe-	3.3	2.5	2.0	2.4	3.6
Ca-	5.3	2.0	2.4	1.4	2.8
Mg	1.6	0.85	0.69	1.2	1.5
Na-	3.2	4.5	4.5	7.4	5.2
K-	3.7	1.7	2.5	2.9	1.9
Ba-	TR<0.05	0.052	0.054	0.053	0.079
B-	0.0042	ND<0.003	ND<0.003	TR<0.003	ND<0.003
Ti-	0.50	0.42	0.27	0.53	0.57
Pb-	TR<0.01	----------	----------	----------	--->
Ga-	0.0068	0.0039	0.0032	0.0048	0.0061
Mn-	0.050	0.059	0.055	0.040	0.063
V-	0.0094	0.0084	0.0076	0.0092	0.0087
Cu-	0.0042	0.0030	0.0049	0.0067	0.0059
Ag-	ND<0.0001	ND<0.0001	TR<0.0001	ND<0.0001	ND<0.0001
Ni-	0.0034	0.0032	0.0031	0.0044	0.0046
Zr-	0.021	0.025	0.025	0.039	0.028
Co-	0.0028	0.0023	0.0021	0.0024	0.0040
Cr-	0.035	0.013	0.027	0.054	0.032
Sr-	0.0020	0.0023	0.0021	0.0022	0.0019
Other elements	Nil	----------	----------	----------	--->

Table 6

Yield of Corn Plants From
Range Finding Hydroponic Tests

Conc. of Contaminant (ppm)	Type of Contaminant	Yield (Fresh Wt. (G)			
		Silk	Stem	Whole Cob	Husk
0	DIMP	3.2	7.0	83.6	18.8
1	"	2.1	4.3	76.2	8.2
10	"	1.9	7.9	119.4	6.5
100	"	4.4	2.4	2.8	9.8
1000	"	*	*	*	*
0	DCPD	1.4	2.7	51.5	2.6
1	"	2.2	8.1	41.1	6.0
10	"	1.4	5.4	86.8	2.6
100	"	1.2	8.9	96.3	3.9
1000	"	1.15	0.8	1.6	1.7

* Never achieved maturity

Table 7

DIMP Concentration in Hydroponically Grown Corn Plant Parts at Harvest

Concentration of Contaminent	DIMP Concentration (ppm) (fresh cut basis)		
	Silk	Kernel	Husk
1	7.0	0	1.3
10	6.0	0.8 maybe not bad	13.8
100	51.5	125.7	188.6
1000	*	*	*

* Never reached maturity

Table 8

% Loss on Drying of Various Corn Parts

DIMP Level in Nutrient / Plant Part	Control	1 ppm	10 ppm	100 ppm
Husk	83.4	80.6	62.3	73.4
Silk	77.2	68.7	52.9	92.2
Kernel	60.0	58.3	54.6	84.6

Applying the weight loss factors from Table 8 to the DIMP concentration figures in Table 7 the bioaccumulation factors in Table 9 were determined.

Table 9

DIMP Bioaccumulation Factors for Corn Parts
(Dry Weight Basis)

Concentration of Contaminant (ppm)	Bioaccumulation Factor		
	Silk	Kernel	Husk
1	22.3	0	6.7
10	1.3	1.8	3.7
100	6.6	8.2	7.1

Further assays in this section are continuing.

DCPD Analysis

Gas chromatographic columns have been prepared consisting of 1/8" diameter stainless steel tubing containing 10% OV-17 on Chromosorb G 60/80. This

is the column packing recommended by Rocky Mountain Arsenal. Solutions of standard DCPD in carbon disulfide were prepared and chromatographed on this column using various instrumental parameters. Figure 2 shows the chromatograms obtained for standards up to 1000 ppm DCPD run at 20 psig carrier gas pressure. Figure 3 shows chromatograms obtained for the same standards up to 10 ppm at 28 psig carrier gas pressure. Plotting the integrated areas under the chromatograms versus concentration gave the standard curves shown in Figure 4. The linear portion of the curves extends at least to 1000 ppm concentration. Using this same chromatographic set up it was not possible to measure these concentrations of DCPD in water, methanol or chloroform. This leaves carbon disulfide as the solvent of choice for these concentrations at this time.

It has been claimed that DCPD in water at 10 part per billion concentration can be analyzed by this chromatographic system. This is achieved by agitating 100 ml. of a 10 ppb solution with 1.0 ml of carbon disulfide and allowing it to separate. The CS_2 extracts essentially all of the DCPD from the water and is immiscible with the water. This process results in a CS_2 solution of DCPD at a concentration level of 1.0 part per million. This level can be measured chromatographically as demonstrated in the standard chromatograms shown.

This system will be used for analysis of water samples. The applicability and/or modification of this system for use on soil and plant extract samples will be investigated.

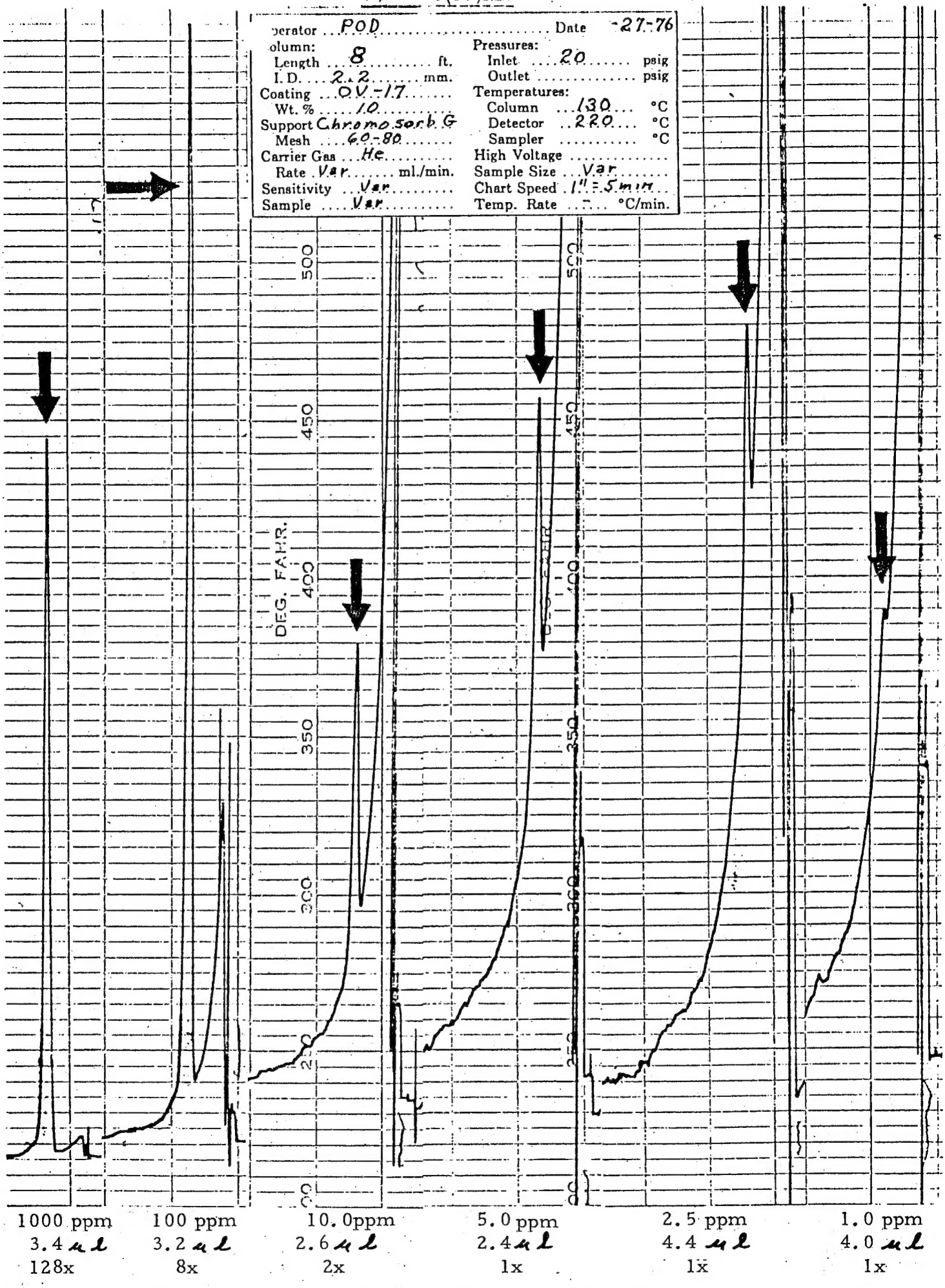

Figure 2 . Gas Chromatographic Analysis of Standard Solutions of Dicyclopentadiene in Carbon Disulfide /

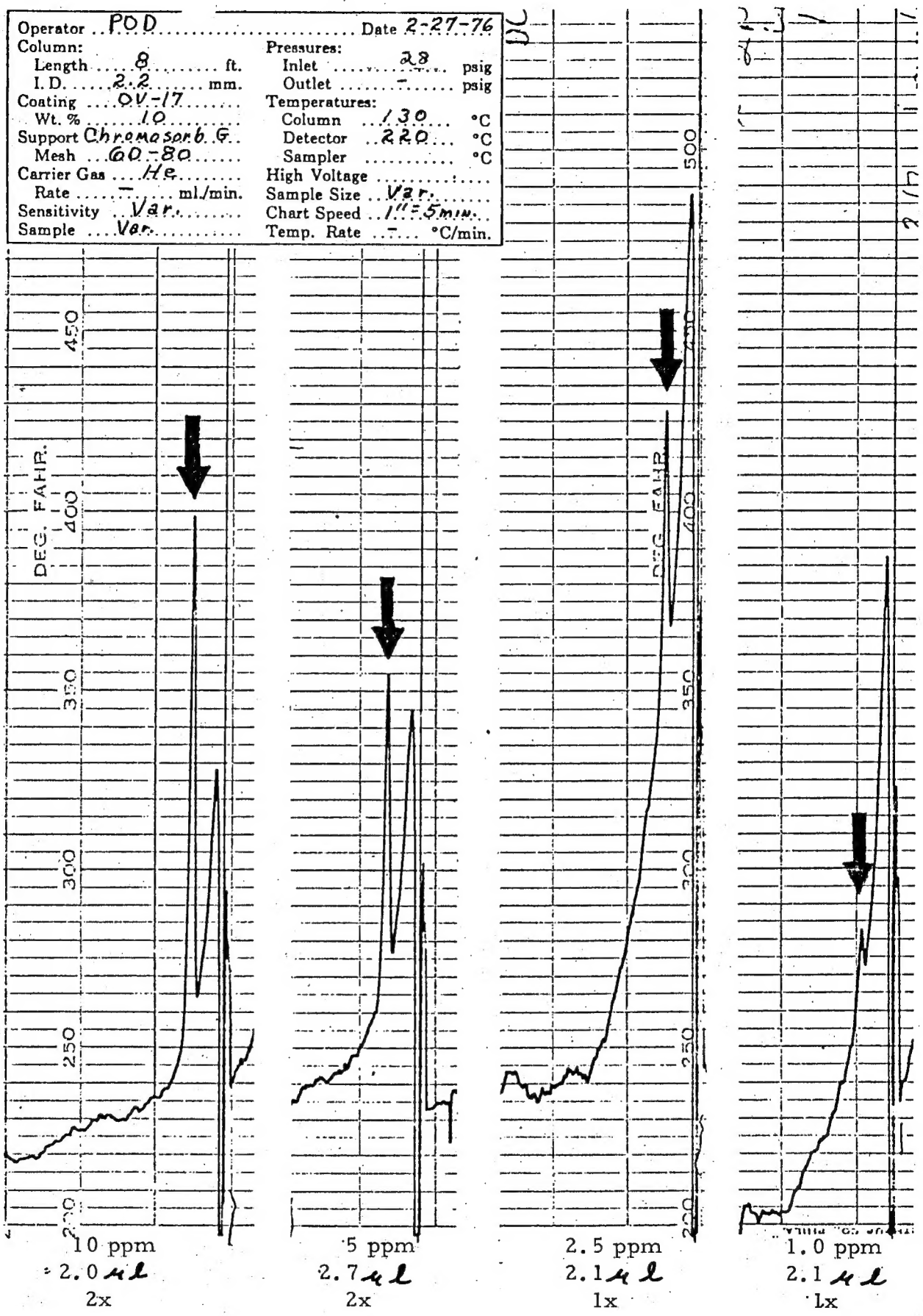

Figure 3. Gas Chromatographic Analysis of Standard Solutions of Dicyclopentadiene in Carbon Disulfide.

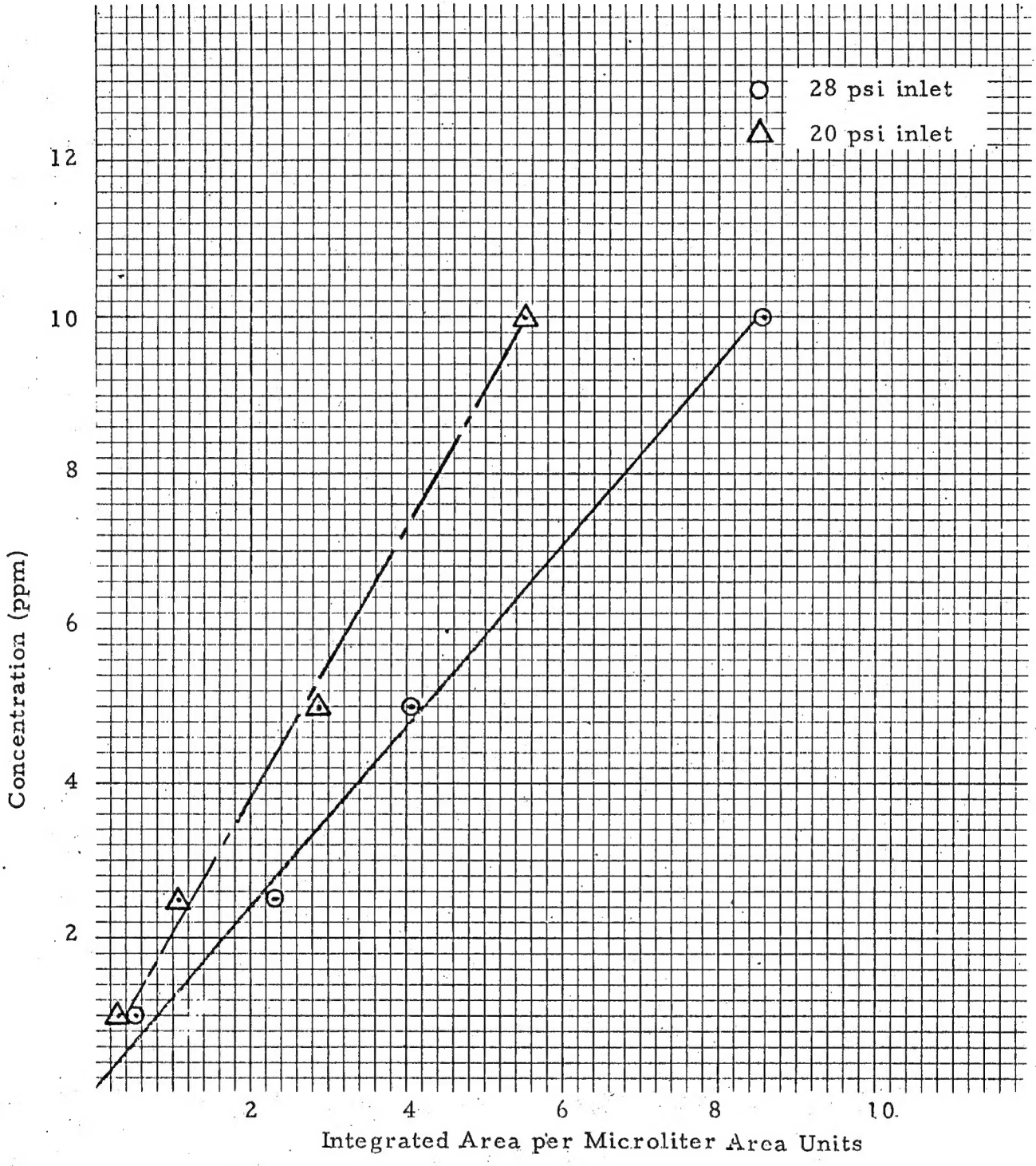

Fig. 4. Standard Curves for GLC Analysis of Dicyclopentadiene in Carbon Disulfide.

Proposed Activity during March 1976

- Analysis of DIMP mobility in the large scale lysimeters.
- Harvest and analysis of the range finding plant growth experiments.
- Begin construction of additional greenhouse facilities for the expanded soil culture experiments.
- Continue laboratory scale soil/additive experiments.
- Investigate RMA procedure for DCPD in water analysis and investigate its application to soil and plant materials.